Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

A COMPUTER PROGRAM TO CALCULATE THE RANK OF A COAL

G.R. Corbett and G.W. Bonnell
Cape Breton Coal Research Laboratory

October 1986

This document is an interim report prepared ... for discussion and information ... Energy, Mines and Resources Canada (CANMET)

Ce document est un rapport ... préparé ... de discussions ... Énergie, Mines et Ressources Canada (CANMET)

15 pp

ENERGY RESEARCH PROGRAM
COAL RESEARCH LABORATORIES
DIVISION REPORT ERP/CRL 86-115(TR)

MICROMEDIA

A COMPUTER PROGRAM TO CALCULATE THE RANK OF A COAL

by

G.R. Corbett* and G.W. Bonnell**

SUMMARY

This report describes the computer program 'RANK.BAS' which classifies coal according to rank using method D 388-84 of the American Society for Testing and Materials (ASTM).

The program is written in Basic (Version 3.1) for use on an IBM-PC/AT or compatible microcomputer.

---

*Laboratory and Field Technologist and **Supervising Chemist, Cape Breton Coal Research Laboratory, CRL, Energy, Mines and Resources Canada, Sydney.

UN PROGRAMME MACHINE POUR DÉTERMINER LE RANG D'UN CHARBON

par

G.R. Corbett* et G.W. Bonnell**

RÉSUMÉ

Le présent rapport donne une brève description du programme machine "RANK.BAS" qui permet de classer le charbon selon un rang à l'aide de la méthode D 388-84 de l'American Society for Testing and Materials (ASTM).

Ce programme est écrit en langage BASIC (Version 3.1) et peut être utilisé sur un micro-ordinateur IMB-PC/AT ou tout autre micro-ordinateur compatible.

---

*Technologue de laboratoire et in situ et ** chimiste superviseur, Laboratoire de recherche sur le charbon du Cap-Breton, LRC, Énergie, Mines et Ressources Canada, Sydney.

CONTENTS

	Page
SUMMARY	i
SOMMAIRE	iii
INTRODUCTION	1
PROGRAM ACCESS	1
PROGRAM OPERATION	3
REMARKS	4
REFERENCES	4
APPENDIX A	7

TABLES

1.	Classification of Coals by Rank	2
2.	Sample of program printout	5
3.	Program description	6

INTRODUCTION

The rank of the coal indicates the degree to which the original organic matter has been metamorphosed by temperature and pressure over time to form lignitic, subbituminous, bituminous or anthracitic coals. Rank is important commercially because, within wide limits, it signifies the potential use of the coal, subject to considerations related to quality factors such as moisture, ash, sulfur and trace element content. Rank classification is made according to fixed carbon and calorific value (BTU) calculated on a mineral-matter-free basis. Higher ranked coals are classified according to fixed carbon on a dry basis whereas lower ranked coals are classified according to calorific value on a moist basis. The agglomerating characteristics of the coal is used to differentiate between coals which otherwise may overlap by group (Table 1).

"Moist basis" refers to coal containing its natural inherent or bed moisture, but not including water adhering to the surface of the coal. Equilibrium moisture provides a means of estimating the natural bed moisture exclusive of surface moisture. If the natural inherent or bed moisture is not available, then the rank of a coal may be "approximated" using the air-dry moisture basis (this applies only to coals which would be classified as high-volatile A bituminous). For coal ranked higher than high-volatile A bituminous (i.e. dry, mineral-matter-free fixed carbon is greater than 69%) heating values are not needed for classification and consequently any moist basis (including dry basis may be used).

This report presents a computer program which classifies coal according to rank using the American Society for Testing and Materials (ASTM) procedure D 388-84, "Classification of Coals by Rank".

PROGRAM ACCESS

The program 'RANK.BAS' was written for use on an IBM-PC/AT or compatible microcomputer. The following is a list of the hardware/software used: a) two "floppy" disk drives, b) 320 kB, 5 1/4" double-sided, double-density, soft sectored diskettes, c) DOS operating system (Version 3.1),

TABLE 1 Classification of Coals by Rank[A]

Class	Group	Fixed Carbon Limits, percent (Dry, Mineral-Matter-Free Basis)		Volatile Matter Limits, percent (Dry, Mineral-Matter-Free Basis)		Calorific Value Limits, Btu per pound (Moist,[B] Mineral-Matter-Free Basis)		Agglomerating Character
		Equal or Greater Than	Less Than	Greater Than	Equal or Less Than	Equal or Greater Than	Less Than	
I. Anthracitic	1. Meta-anthracite	98	...	...	2	...	...	nonagglomerating
	2. Anthracite	92	98	2	8	...	...	
	3. Semianthracite[C]	86	92	8	14	...	...	
II. Bituminous	1. Low volatile bituminous coal	78	86	14	22	...	...	commonly agglomerating[E]
	2. Medium volatile bituminous coal	69	78	22	31	...	...	
	3. High volatile *A* bituminous coal	...	69	31	...	14 000[D]	...	
	4. High volatile *B* bituminous coal	...	...	...	...	13 000[D]	14 000	
	5. High volatile *C* bituminous coal	...	...	...	...	11 500	13 000	agglomerating
						10 500	11 500	
III. Subbituminous	1. Subbituminous *A* coal	...	...	...	...	10 500	11 500	nonagglomerating
	2. Subbituminous *B* coal	...	...	...	...	9 500	10 500	
	3. Subbituminous *C* coal	...	...	...	...	8 300	9 500	
IV. Lignitic	1. Lignite *A*	...	...	...	...	6 300	8 300	
	2. Lignite *B*	...	...	...	...	...	6 300	

[A] This classification does not apply to certain coals, as discussed in Note 1.
[B] Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.
[C] If agglomerating, classify in low-volatile group of the bituminous class.
[D] Coals having 69 % or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of calorific value.
[E] It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and that there are notable exceptions in high volatile *C* bituminous group.

d) Basic or Basic A language (Version 3.1) and e) IBM compatible printer (if hardcopy is desired).

In order to use this program 'RANK.BAS' it is assumed that there are two disk drives A: and B:. The diskette containing the operating system and Basic (Basic A) language is mounted into the A: drive and the diskette containing the application program 'RANK.BAS' is mounted into the B: drive. To speed up program operation, a second small program was written 'RANK.BAT'. Once the user inserts the program diskette, all that is required is to type B: <carriage return> and then 'RANK' <carriage return>. 'RANK.BAT' will automatically load and execute 'RANK.BAS'. The following is a program listing for 'RANK.BAT':

```
CLS
ECHO OFF
A: BASIC A
RANK
```

If 'RANK.BAT' is not used, then the following procedure may be used: mount the diskette containing the operating system (DOS) and Basic (Basic A) language into drive A:. Press <carriage return> and when operating system is loaded type in 'BASIC' or 'BASIC A'. Mount the application diskette containing the program 'RANK.BAS' into drive B:. Type in 'LOAD "B:RANK' and then <carriage return>. Finally, type in 'RUN' <carriage return>.

PROGRAM OPERATION

Through a series of prompts the user must input the following data:

Sample Identification
% Moisture
% Ash
% Volatile Matter
% Sulfur
Calorific Value (BTU)
Agglomerating (Y or N)

Upon completion of the data input, the program calculates and displays the dry, mineral-matter-free fixed carbon, dry, mineral-matter-free volatile matter and moist, mineral-matter-free calorific value (BTU) using the Parr Formulas from D 388-84 of the American Society for Testing and Materials (ASTM). The classification of the coal by rank is then determined if possible and displayed (Table 2). The user will then be prompted as to whether he wants a hardcopy or not. If a hardcopy is needed, the following procedure may be used: 1) Turn printer on (make sure it is "on line"), 2) Press <carriage return> and 3) Press shift and PrtSc keys simultaneously. When printing is complete press any key to return to the program. A final prompt requests whether you wish to determine the rank of another coal sample. See Table 3 for a brief program description. For a complete listing of 'RANK.BAS' see Appendix A.

REMARKS

The program 'RANK.BAS' allows the user to determine the rank and obtain a hardcopy of as many coal samples as desired.

Proper sampling and analysis techniques as presented in Volume 05.05 of the American Society for Testing and Materials (ASTM) should be followed in order to accurately assess coal rank. It should be stressed that the proper "moist basis" be used as outlined in paragraphs 2 and 3 of the introduction in this report.

Users of this computer program should save time by avoiding tedious hand calculations, particularly when numerous samples are involved.

REFERENCES

1. American Society for Testing and Materials (ASTM); Vol. 05.05; Coal and Coke Method D 388-84; "Classification of Coals by Rank".
2. Bonnell, G.W. and Janke, L.C. "Analysis Directory of Canadian Commerical Coals - Supplement No. 6"; CANMET Report CM85-11E; CANMET, Energy, Mines and Resources Canada, 1986.

```
SAMPLE IDENTIFICATION                    TEST SAMPLE # 1

MOISTURE          (  %  )                2.01
ASH               (  %  )                12.59
VOLATILE          (  %  )                34.21
SULFUR            (  %  )                3.22
CALORIFIC VALUE (B.T.U.)                 12833
IS THIS COAL AGLOMERATING ( Y OR N )? Y

DRY,MINERAL MATTER FREE FIXED CARBON  56.11 %
DRY,MINERAL MATTER FREE VOLATILE      43.89 %
DRY,MINERAL MATTER FREE B.T.U.      14973.10 B.T.U.

*** THE RANK OF THIS SAMPLE IS HIGH VOLATILE A BITUMINOUS COAL ***
```

```
SAMPLE IDENTIFICATION                    TEST SAMPLE # 2

MOISTURE          (  %  )                1.21
ASH               (  %  )                13.55
VOLATILE          (  %  )                32.11
SULFUR            (  %  )                3.00
CALORIFIC VALUE (B.T.U.)                 1553
IS THIS COAL AGLOMERATING ( Y OR N )? N

DRY,MINERAL MATTER FREE FIXED CARBON  58.94 %
DRY,MINERAL MATTER FREE VOLATILE      41.06 %
DRY,MINERAL MATTER FREE B.T.U.      1675.90 B.T.U.

*** THE RANK OF THIS SAMPLE IS LIGNITE B ***
```

Table 2 - Sample of program printout

Table 3 - Program description

10 - 100	Program description
110 - 170	Screen initiation
180 - 460	Program explanation
470 - 720	Input and variables
730 - 800	Calculations necessary to determine rank
810 - 900	Screen printout of calculated values
910 - 1120	Searching values to determine rank
1130 - 1380	Screen printout of determined rank
1390 - 1580	Routine to print out hardcopy if desired
1590 - 1660	Routine to return to calculate another sample or end
1670 - 1730	Subroutine to handle erroneous input.

APPENDIX A

```
10 REM ************************************************************************
20 REM ************************************************************************
30 REM *  PROGRAM   :              RANK                                        *
40 REM *                                                                      *
50 REM *            A PROGRAM TO CALCULATE THE RANK OF A COAL                 *
60 REM *  WRITTEN BY: G.W.BONNELL FOR THE NORTHSTAR ADVANTAGE GBASIC           *
70 REM *  WRITTEN BY: G.R.CORBETT FOR THE IBM.PC/AT VERSION 3.1 BASICA         *
80 REM *            DEPARTMENT OF ENERGY,MINES AND RESOURCES                  *
71 REM *            CANMET / CAPE BRETON COAL RESEARCH LABORATORY             *
72 REM *            210 GEORGE ST., SYDNEY, NOVA SCOTIA  B1P 1J3              *
90 REM ************************************************************************
100 REM ***********************************************************************
110 REM
120 REM ***********************************************************************
130 REM *                    SETTING OPENING PARAMETERS                       *
140 REM ***********************************************************************
150 DIM I$(45)
160 KEY OFF
170 CLS
180 REM ***********************************************************************
190 REM *                    EXPLANATION AT OPENING                           *
200 REM ***********************************************************************
210 PRINT "                                *** R A N K ***                    "
220 PRINT "                 - A PROGRAM TO DETERMINE THE RANK OF A COAL -     "
230 PRINT:PRINT
240 PRINT" :  ENTER THE FOLLOWING VALUES ON AN INHERENT OR EQUILIBRIUM";
250 PRINT   " MOISTURE BASIS:"
260 PRINT"    (1) MOISTURE ;(2) ASH ;(3) VOLATILE MATTER ;(4) SULFUR ";
270 PRINT   ";(5) B.T.U."
280 PRINT
290 PRINT" :  IF THE B.T.U. VALUE IS NOT AVAILABLE ,ZERO (0) SHOULD BE ";
300 PRINT    "ENTERED."
310 PRINT"    RANK MAY STILL BE DETERMINED IF THE DRY,MINERAL-MATTER-FREE ";
320 PRINT"    FIXED CARBON IS GREATER THAN 69 % ."
330 PRINT
340 PRINT" :  FOR VALUES ENTERED ON A DRY BASIS (ie. ENTERED MOISTURE = 0), ";
350 PRINT    "ONLY DRY,"
360 PRINT"    MINERAL-MATTER-FREE FIXED CARBON AND DRY,MINERAL-MATTER-FREE ";
370 PRINT    "VOLATILE ";
380 PRINT"    MAY BE DETERMINED."
390 PRINT
400 PRINT" :  FOR ADDITIONAL INFORMATION, PLEASE SEE ASTM's METHOD D ";
410 PRINT "388-84. "
420 PRINT:PRINT:PRINT:PRINT "                              HIT ANY KEY TO CONTINUE"
430 S$=INKEY$: IF S$="" THEN 430
```

```
440 REM ************************************************************************
450 REM *          INPUT DATA TO BE CALCULATED    M,A,V,S,BTU                  *
460 REM ************************************************************************
470 CLS
480 PRINT "                                                                    ";
490 PRINT "                                                                    ";
500 PRINT "           *"
510 PRINT CHR$(30);CHR$(30)
520 PRINT CHR$(30);CHR$(30)                                    "
530 INPUT "       SAMPLE IDENTIFICATION     *",I$
540 PRINT
550 INPUT "       MOISTURE          ( %  )                    ",M
560 IF M>100 OR M<0 THEN 570 ELSE 580
570 GOSUB 1750:GOTO 550
580 INPUT "       ASH               ( %  )                    ",A
590 IF A>100 OR A<0 THEN 600 ELSE 610
600 GOSUB 1750:GOTO 580
610 INPUT "       VOLATILE          ( %  )                    ",V
620 IF V>100 OR V<0 THEN 630 ELSE 640
630 GOSUB 1750:GOTO 610
640 INPUT "       SULFUR            ( %  )                    ",S
650 IF S>100 OR S<0 THEN 660 ELSE 670
660 GOSUB 1750:GOTO 640
670 INPUT "       CALORIFIC VALUE (B.T.U.)                    ",B
680 IF B>20000 OR B<0 THEN 690 ELSE 700
690 GOSUB 1750:GOTO 670
700 PRINT "       IS THIS COAL AGGLOMERATING ( Y OR N )?"
710 G$=INKEY$: IF G$="" THEN 710
720 IF G$="Y" OR G$="y" OR G$="N" OR G$="n" THEN 740 ELSE 730
730 GOSUB 1740 :GOTO 700
740 PRINT "                                                    ";CHR$(30);G$
750 REM ************************************************************************
760 REM *             CALCULATIONS FOR DETERMINING RANK                          *
770 REM ************************************************************************
780 F=100-(M+A+V)
790 PRINT
800 X=(F-(1.5*S))/(100-(M+(1.08*A)+(.55*S)))*100
810 Y=100-X
820 Z=(B-(50*S))/(100-((1.08*A)+(.55*S)))*100
830 REM ************************************************************************
840 REM *            PRINTOUT TO SCREEN OF FINAL VALUES                          *
850 REM ************************************************************************
860 PRINT USING "      DRY,MINERAL-MATTER-FREE FIXED CARBON  ##.##";X;
870 PRINT " %"
880 PRINT USING "      DRY,MINERAL-MATTER-FREE VOLATILE       ##.##";Y;
890 PRINT " %"
900 IF B>0 THEN 910 ELSE 960
910 PRINT USING "      MOIST,MINERAL-MATTER-FREE B.T.U.    #####.##";Z;
920 PRINT " B.T.U."
```

```
930 REM ************************************************************************
940 REM *          SEARCHING CALCULATED VARIABLES TO PRINT OUT RANK            *
950 REM ************************************************************************
960 IF B=0 AND X<69 THEN 1350
970 IF B=0 AND X>=69 THEN GOSUB 1380
980 GOSUB 1420
990 IF X>=98 THEN 1180
1000 IF X>=92 AND X<98 THEN 1190
1010 IF X>=86 AND X<92 THEN 1200
1020 IF X>=78 AND X<86 THEN 1220
1030 IF X>=69 AND X<78 THEN 1230
1040 IF X<69 AND Z>=14000 THEN 1240
1050 IF X<69 AND Z<14000 AND Z>=13000 THEN 1250
1060 IF X<69 AND Z<13000 AND Z>=11500 THEN 1260
1070 IF G$="Y" THEN 1080 ELSE 1090
1080 IF X<69 AND Z<11500 AND Z>=10500 THEN 1260
1090 IF X<69 AND Z<11500 AND Z>=10500 THEN 1280
1100 IF X<69 AND Z<10500 AND Z>=9500 THEN  1290
1110 IF X<69 AND Z<9500 AND Z>=8300 THEN 1300
1120 IF X<69 AND Z<8300 AND Z>=6300 THEN 1320
1130 IF X<69 AND Z<6300 THEN 1330
1140 GOTO 1460
1150 REM ************************************************************************
1160 REM *       PRINTOUT TO SCREEN OF RANKINGS BASED ON CALCULATED DATA       *
1170 REM ************************************************************************
1180 PRINT "META-ANTHRACITE  ***":GOTO 1460
1190 PRINT "ANTHRACITE  ***":GOTO 1460
1200 PRINT "SEMIANTHRACITE  ***":GOTO 1460
1210 REM
1220 PRINT "LOW-VOLATILE BITUMINOUS  ***":GOTO 1460
1230 PRINT "MEDIUM-VOLATILE BITUMINOUS  ***":GOTO 1460
1240 PRINT "HIGH-VOLATILE A BITUMINOUS  ***":GOTO 1460
1250 PRINT "HIGH-VOLATILE B BITUMINOUS  ***":GOTO 1460
1260 PRINT "HIGH-VOLATILE C BITUMINOUS  ***":GOTO 1460
1270 REM
1280 PRINT "SUBBITUMINOUS A  ***":GOTO 1460
1290 PRINT "SUBBITUMINOUS B  ***":GOTO 1460
1300 PRINT "SUBBITUMINOUS C  ***":GOTO 1460
1310 REM
1320 PRINT "LIGNITE A  ***":GOTO 1460
1330 PRINT "LIGNITE B  ***":GOTO 1460
1340 REM
```

```
1350 PRINT:PRINT
1360 PRINT"B.T.U. VALUE IS NEEDED TO CALCULATE THIS SAMPLE'S RANK":GOTO 1460
1370 PRINT
1380 PRINT
1390 PRINT"       ***  RANK MAY BE DETERMINED EVEN THOUGH B.T.U. IS ZERO  ***"
1400 RETURN
1410 REM
1420 PRINT:PRINT *       *** THE RANK OF THIS COAL SAMPLE IS "; :RETURN
1430 REM ************************************************************************
1440 REM *              HARDCOPY PRINTOUT USING PRINTSCREEN KEY                 *
1450 REM ************************************************************************
1460 PRINT:PRINT:PRINT
1470 PRINT "DO YOU WANT A HARDCOPY ( Y OR N ) ?"
1480 H$=INKEY$:IF H$="" THEN 1480
1490 IF H$="Y" OR H$="y" THEN 1500 ELSE 1620
1500 PRINT "DIRECTIONS FOR HARDCOPY":PRINT "(1) TURN PRINTER ON ";
1510 PRINT "(2) PRESS RETURN KEY"
1520 PRINT "(3) PRESS SHIFT AND PrtSc SIMULTANEOUSLY"
1530 INPUT "",F$
1540 PRINT CHR$(30);CHR$(30);CHR$(30);CHR$(30);CHR$(30);CHR$(30);CHR$(30)
1550 PRINT  *                                                                  *
1560 PRINT  *                                                                  *
1570 PRINT  *                                                                  *
1580 PRINT  *                                                                  *
1590 PRINT  *                                                                  *
1600 PRINT  *                                                                  *
1610 Y$=INKEY$:IF Y$="" THEN 1610
1620 FOR I=1 TO 3  : PRINT CHR$(30) : NEXT
1630  REM ************************************************************************
1640  REM *           CALCULATE ANOTHER SAMPLE OR EXIT TO D.O.S                  *
1650  REM ************************************************************************
1660 PRINT "DO YOU WISH TO DETERMINE THE RANK OF ANOTHER SAMPLE (Y OR N) ?"
1670 A$=INKEY$: IF A$="" THEN 1670
1680 IF A$="N" OR A$="n" THEN 1690 ELSE 470
1690 CLS:SYSTEM
1700 END
1710  REM ************************************************************************
1720  REM *    SUBROUTINE TO HANDLE ERRONIOUS INPUT OF M,A,V,S,BTU etc.        *
1730  REM ************************************************************************
1740 PRINT CHR$(30);CHR$(30);CHR$(7):RETURN
1750 PRINT CHR$(30);CHR$(30):GOSUB 1760:GOSUB 1740:RETURN
1760 PRINT *                                                                   *
1770 RETURN
```